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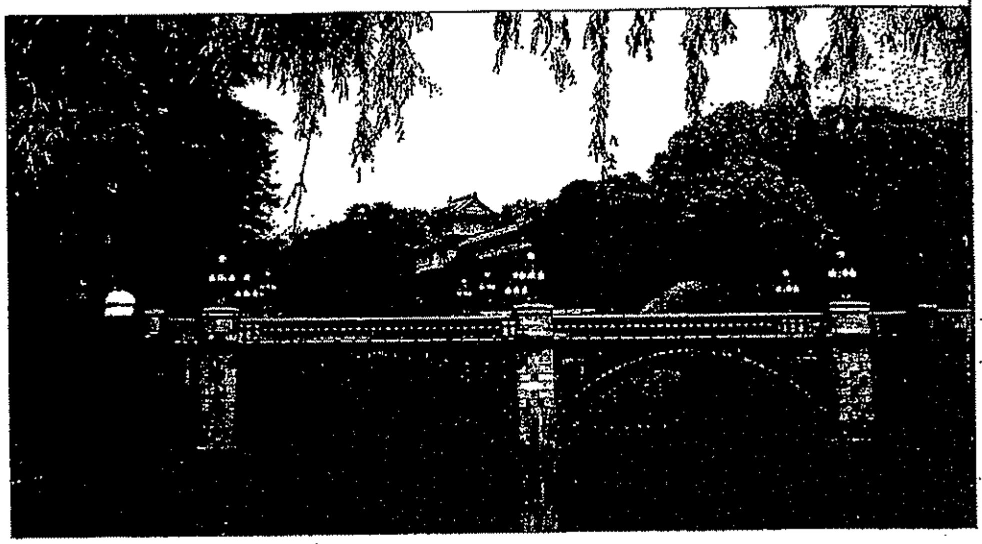

Technology Series

Intrusion Detection

Rebecca Gurley Bace

INTRUSION DETECTION

Rebecca Gurley Bace

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Rebecca Gurley Bace

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CHAPTER 1

The History of Intrusion Detection

"Life was simple before World War II. After that, we had systems."
- Admiral Grace Hopper

When I explain intrusion detection to those not familiar with network security, it's usually easy to describe what intrusion detection systems do: "It's a burglar alarm for computers and networks," or "It looks for criminals breaking into a computer system and lets someone know about it." Most people understand that when systems handle things that are considered valuable, the systems themselves are natural targets of attack.

Although the goals of intrusion detection systems may be intuitively obvious to both technical and nontechnical users, many people are not aware of the history of intrusion detection research and development. This lack of information results in repeating mistakes made in the past or needlessly settling for suboptimal approaches to critical functions.

Intrusion detection has merged traditional electronic data processing (EDP) and security audit with optimized pattern-matching and statistical techniques. Intrusion detection has become an integral part of modern network security technology. In this section, I describe the history of audit and intrusion detection from the perspective of the people who did the initial research and development and their projects.

1.1 Audit: Setting the Stage for Intrusion Detection

Before intrusion detection, there was audit. *Audit* is defined as the process of generating, recording, and reviewing a chronological record of system events. People audit systems to accomplish a variety of goals. These goals include the following:

- To assign and maintain personal accountability for system activities
- To reconstruct events
- To assess damage

1.1.4 Audit and Military Models of Computer Security

The U.S. Department of Defense (DOD) backed an extensive research effort during the 1970s, which explored security policies, guidelines, and controls for operating "trusted systems," culminating in the DOD Security Initiative of 1977.

Trusted systems were defined as "systems that employ sufficient hardware and software assurance measures to allow their use for simultaneous processing of a range of sensitive or classified information."[3] Thus, trusted systems were designed from the ground up in a way that allowed military and intelligence organizations to place information of different sensitivity levels (typically corresponding to levels of classification) on the same computer system. The Trusted Systems Initiative provided a venue in which the computer security experts of the era explored the features and protections that were necessary for trusted systems to function. (Trusted systems are discussed in more depth in Chapter 3.)

During the initial explorations, researchers debated whether security audit mechanisms would contribute to the assurance level of a trusted system. Ultimately, the audit mechanism was indeed included as part of the *Trusted Computer System Evaluation Criteria*[4] ("Orange Book") requirements for systems evaluated at trust levels C2 and above. The series of documents that outlined the DOD's Trusted Systems Initiative are often referred to as the "Rainbow series," in a reference to the brightly colored covers of the documents.

A document, which addresses the issue of audit in trusted systems, is included in the Rainbow series. It is the "Tan Book," titled *A Guide to Understanding Audit in Trusted Systems.*

The Tan Book outlines five security goals for audit mechanisms:

- To allow the review of patterns of access (on a per-object and per-user basis) and the use of protection mechanisms of the system
- To allow the discovery of both insider and outsider attempts to bypass protection mechanisms
- To allow the discovery of a transition of a user from a lesser to a greater privilege level; for example, when a user moves from clerical to system administrator roles
- To serve as a deterrent to users' attempts to bypass system-protection mechanisms
- To serve as yet another form of user assurance that attempts to bypass the protection will be recorded and discovered, with sufficient information recorded to allow damage control

Although the Tan Book (as well as much of the Rainbow series) reflects a rather centralized mainframe view of computing, its principles of security audit still apply.[5]

Note

MIDAS, one of the first intrusion detection systems that monitored an operational system connected to the Internet, gave a fascinating view of the Internet threat. Dockmaster was an attractive target for attack due to its affiliation with the Defense Department. Perhaps the most interesting insight that MIDAS gave us was a demonstration of the value of strong identification and authentication (I&A) mechanisms. In the late 1980s, after MIDAS came online, the NCSC decided to utilize token-based I&A as a replacement for weaker password mechanisms. In the scheme selected, users had a calculator-style token, protected by a PIN. When someone logged into Dockmaster, the system issued a multidigit challenge; this challenge was entered into the token, and the resulting multidigit response was sent back to Dockmaster, at which time the user session began.

MIDAS allowed the Dockmaster security staff to see the effects of enacting this stronger login mechanism. Doorknob-rattling and password-guessing incidents dropped dramatically after the token-based I&A system was in place. This effect emphasizes again the importance of thinking holistically when determining a protection strategy for systems.

The intrusion detection system could have continued to record attempts to hack into the system by password-guessing or other such attacks on weaker I&A mechanisms. Attackers might have been deterred, but only after a great deal of time and energy were spent on investigating the incident—tracking down the attacker, going through the phases of a criminal investigation and prosecution, and hoping for a sufficiently harsh sentence to discourage further attacks. The desired effect (to make external attackers stop) was much more quickly and easily accomplished by using a strong protection mechanism at the system access point.

Another even more important point is that, despite strengthening I&A to a point where external attackers were thwarted, the organization continued to run MIDAS to monitor for insider abuse.

1.2.3.5 NADIR

Network Audit Director and Intrusion Reporter[14] (NADIR) was developed by the Computing Division of Los Alamos National Laboratory to monitor user activities on the Integrated Computing Network (ICN) at Los Alamos. This network is Los Alamos's main computer network and serves more than 9,000 users—connecting supercomputers, local and remote terminals, workstations, network services machines, and data communications interfaces. NADIR monitors the network by processing audit trails generated by specialized network service nodes. It was designed to run on Sun UNIX workstations and, like many other systems of the time, it performs a combination of expert rule-based analysis and statistical profiling. NADIR is written in SQL an

runs on a Sybase database management system, using some of Sybase's internal triggers and other features.

NADIR remains one of the most successful and durable intrusion detection systems of the 1980s and has been extended to monitor systems beyond the ICN at Los Alamos. NADIR continues to monitor the ICN at the time of this publication, and the team continues to modify the system to accommodate new threats and target systems. The principal architect for NADIR is Kathleen Jackson.

1.2.3.6 NSM

The Network System Monitor (NSM) was developed at the University of California at Davis to run on a Sun UNIX workstation. It represented the first foray into monitoring network traffic and using that traffic as the primary data source. Before this time, most intrusion detection systems consumed information from operating system audit trails or keystroke monitors. The general architecture of the NSM is still reflected in many commercial intrusion detection products at the time of this publication. The NSM functioned by doing the following:

- Placing the system's Ethernet network interface card into promiscuous mode (in which each network frame generates an interrupt, thereby allowing the monitoring system to listen to all traffic, not just those packets addressed to the system)
- Capturing network packets
- Parsing the protocol to allow extraction of pertinent features as shown in Figure 1.4
- Using a matrix-based approach to archive and analyze the features, both for statistical variances from normal behavior and for violations of pre-established rules

NSM was a significant milestone in intrusion detection research because it was the first attempt to extend intrusion detection to heterogeneous network environments. It was also one of the first intrusion detection systems to run on an operational system (the computer science department local area network at UC Davis). In a widely cited, two-month test of NSM, it monitored more than 111,000 connections on the network segment, correctly identifying more than 300 of them as intrusions. The system administrators for the network discovered less than one percent of these intrusions. This test emphasized the need for and the effectiveness of intrusion detection systems as part of the protection suite. Principal architects for NSM were Karl Levitt, Todd Heberlein, and Biswanath Mukherjee of the University of California at Davis.[15]

An additional human input comes in the form of user interaction with intrusion detection control components. This type of input can consist of system configuration or policy entry at the time of system installation and setup. It can also take the form of active interaction with the system console, responding to detected problems by directing the system to take additional action. Several generations of intrusion detection systems are likely to be required before detection schemes are mature and reliable enough to allow unsupervised operation. For some environments, the total automation of intrusion detection analysis functions may never be appropriate. In the meantime, you should consider intrusion detection systems as diagnostic tools that allow you to "see" system activity through a security-savvy prism, using this higher-level view to gain additional expertise in recognizing and dealing with security problems.

3.4 *Information from Other Security Products*

In general, the more event information that is considered in performing intrusion detection analysis, the more accurate and sensitive the results. This relationship is especially true in performing intrusion detection on networks, where stand-alone security products are common.

Many firewalls, I&A systems, access control systems, and other security devices and subsystems generate their own activity logs. These logs contain information that is, by definition, of security significance; they are therefore of particular value to the intrusion detection process. Including these logs as information sources is an obvious way to improve the quality of the intrusion detection process.

The process of integrating and analyzing event logs from other components of the system security infrastructure represents a significant and enduring role that intrusion detection systems can play. This role continues to be relevant, even as strong encryption or other measures address those threats we consider of greatest concern today. Although technical environments change, the attack strategies of adversaries remain relatively stable. Because an elementary step in attacking a system is to locate, investigate, and then nullify the existing system protections, monitoring security products will remain a stable requirement.

3.4.1 *An Example of a Security Product Data Source*

Table 3.4 presents a format diagram of the firewall log file generated by Firewall-1, a CheckPoint Technologies product. It allows you to see the transactions processed by the firewall, including mappings of ostensible sources and destinations of connections, the names of system objects associated with the transactions, and other information that was selected for inclusion.